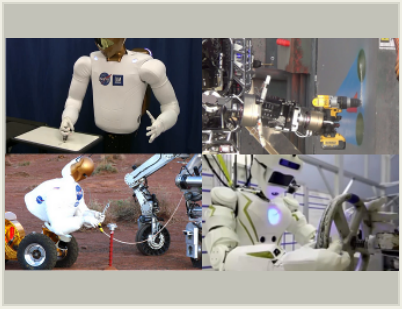
Approximate Cartesian Control for Robotic Tool Usage with Graceful Degradation, Phase I

Completed Technology Project (2014 - 2014)

Project Introduction

Many of NASA's exploration scenarios include important roles for autonomous or partially autonomous robots. It is desirable for them to utilize human tools when possible, rather than needing to build custom tools for each robot. Control of robotic manipulators for tool usage generally requires a very precise Cartesian-space trajectory of the tool tip (e.g., moving a marker along the surface of a whiteboard or rotating a screwdriver about an axis). Well-known techniques exist for manipulator control in Cartesian space, most of which necessitate solving a series of Inverse Kinematics (IK) problems. Closed-form IK solvers work well for 7-degree-of-freedom (DOF) arms with rigid tool attachments, but cannot handle non-rigid tools that slip in the robot's hands. Numerical IK approaches are more generic and can handle non-rigid links to tools, but can be slow to converge. More importantly, if any joints fail or become limited in their range of motion, the robot arm essentially becomes 6-DOF or lower. IK solvers often fail in these lower DOF spaces because the configuration space becomes non-continuous and full of "holes". As a result, a 7-DOF robotic arm in space might be rendered largely useless if a single joint fails or even loses mobility until it can be serviced. TRACLabs proposes to investigate an alternative approach to traditional Cartesian control approaches, which rely on complex IK solvers that go from Cartesian space backwards to joint space. We propose to leverage cheap memory and modern processing speeds to instead perform simple computations that go from joint space forwards to Cartesian space. Such techniques should overcome common changes to a manipulation chain caused by tool slippage or the grasping of a new tool and to overcome uncommon changes to a chain caused by joint failures, reduced joint mobility, changes in joint geometry or range of motion, or added joints.



Approximate Cartesian Control for Robotic Tool Usage with Graceful Degradation Project Image

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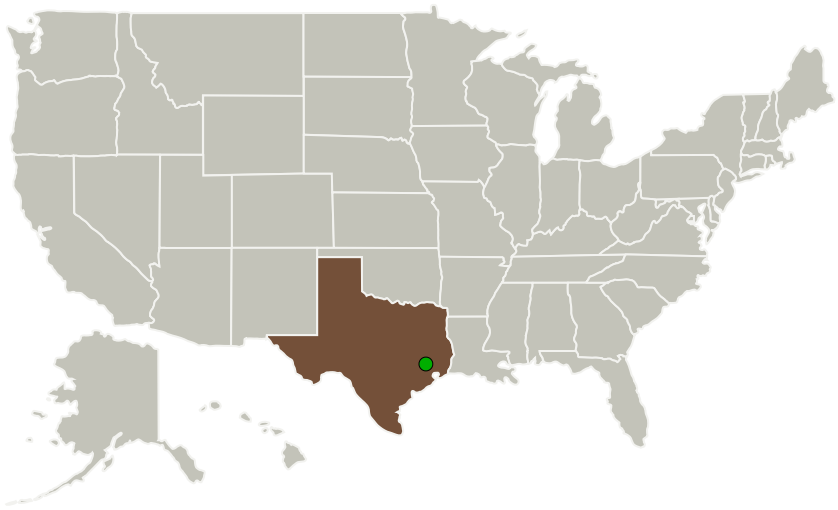
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
TRACLabs, Inc.	Lead Organization	Industry	Webster, Texas
Johnson Space Center(JSC)	Supporting Organization	NASA Center	Houston, Texas

Primary U.S. Work Locations
Texas

Project Transitions

June 2014: Project Start

December 2014: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/140737)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

TRACLabs, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

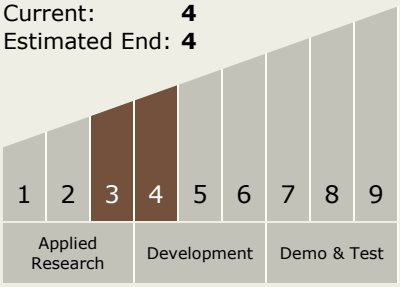
Carlos Torrez

Principal Investigator:

Patrick F Beeson

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**



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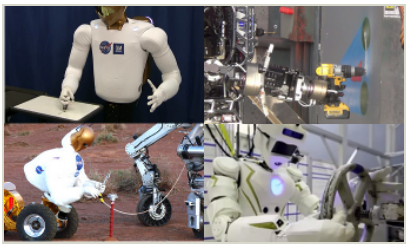
Images



Project Image
Approximate Cartesian Control for Robotic Tool Usage with Graceful Degradation Project Image
(https://techport.nasa.gov/image/127342)

Technology Areas

Primary:

- TX04 Robotic Systems
  - TX04.3 Manipulation
    - TX04.3.2 Grappling Technologies

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System